UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

- X

GERTRUDE NEUMARK ROTHSCHILD, : **ECF CASES**

Plaintiff, :

05 Civ. 5939 (WCC)

- against - :

CREE, INC., :

Defendant.

- X

GERTRUDE NEUMARK ROTHSCHILD, :

05 Civ. 5940 (WCC)

Plaintiff, :

- against - :

PHILIPS LUMILEDS LIGHTING COMPANY L.L.C., FUTURE ELECTRONICS INC. and FUTURE ELECTRONICS CORP., :

OPINION AND ORDER

Defendants. :

- X

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A P P E A R A N C E S : (continued)

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CONNER, Senior D. J.

In these two actions, plaintiff Gertrude Neumark Rothschild charges defendants Cree, Inc. ("Cree") and Philips Lumileds Lighting U.S. LLC ("Lumileds") respectively with infringement of her following United States patents on methods of producing light emitting diodes:

No. 4,904,618, entitled Process for Doping Crystals of Wide Band Gap Semiconductors issued February 27, 1990 on an application filed August 22,1988 ("the '618 patent"); and

No. 5,252,499, entitled Wide Band Gap Semiconductors Having Low Bipolar Resistivity and Method of Formation, issued October 12, 1993 on an application filed August 15, 1988 ('the '499 patent").

A joint *Markman* hearing[1] was conducted in the two actions on March 19, 2007 to determine the proper construction of a number of disputed terms in the claims of the two patents. This opinion incorporates the Court's conclusions as to the proper construction of the claim terms in question.

Claim Construction Principles

In *Phillips v. AWH Corp*., 415 F.3d 1303 (Fed. Cir. 2005), the Court prescribed the proper procedure for determining the meaning of patent claims. The terms of the claims are generally given their customary meaning to a person of ordinary skill in the art at the time of the invention, who is deemed to read the terms not only in the context of the particular claim in which they appear but in

[1] In *Markman* v. *Westview Instruments, Inc.,* 52 F.3d 967, 977-78 (Fed. Cir. 1995) (en banc), *aff'd,* 517 U.S. 370, 388-90 (1996), it was ruled that construction of the terms of the claims is an issue of law to be determined in the first instance by the trial court; in cases tried to a jury, after the court has instructed the jury as to the meaning of the claim terms, the jury determines the factual issues, including infringement, anticipation and obviousness.

the context of the entire patent, including the other claims, the specification and drawing and, if needed, its prosecution history. If, after consideration of such intrinsic evidence, the meaning of a claim term is still uncertain, the Court may look to such extrinsic evidence as expert and inventor testimony, dictionaries and learned treatises. However, the patentee is permitted to be her own lexicographer so that if in the specification she clearly gives a claim term a special definition, that definition controls. (*Id*. at 1316.)

Background Technology

Light emitting diodes, or LEDs, are used by the billions in a multitude of applications, including instrument panels, alphanumeric displays, billboards, traffic lights and as an energy-efficient substitute for incandescent bulbs. LEDs are essentially p-n junctions of wide band gap semiconductor materials. Semiconductors are materials having an electrical conductivity in an intermediate range between insulators and conductors. When an element from Group II of the periodic table, such as zinc (Zn) or cadmium (Cd), having two electrons in its outer shell, is combined with an element from Group VI, such as selenium (Se) or tellurium (Te), having six electrons in its outer shell, a compound having a normal eight electrons in its outer shell, such as zinc selenide (ZnSe), is formed. Likewise such compounds may be formed by combining an element from Group III, such as gallium (Ga), with an element from Group V, such as arsenic (As). The first group of compounds are known as II-VI compounds and the latter group as III-V compounds. If a dopant, or impurity, is incorporated into a crystal of one of these compounds, either during or after crystal growth, the electrical properties of the compound may be changed in a useful manner. For example, if a II-VI compound such as zinc selenide is doped with an element from Group V of the

periodic table, such as nitrogen (N), having five electrons in its outer shell, its atoms displace some of the selenium atoms in the crystal lattice, thereby creating electron acceptors or "holes" in the crystal, making it a "p-type" material. If the dopant is an element from Group III, such as gallium (Ga), having three electrons in its outer shell, its atoms displace some of the zinc atoms in the lattice, creating a excess of electrons in the crystal, making it an n-type material. When a junction is formed between a p-type and an n-type material, and a voltage is applied across the junction, electrons will move from the n-type material to fill the holes in the p-type material and, as they do so, the energy they lose in dropping from the conduction band to the valence band is released in the form of light whose wavelength or color depends on the width of the gap between those bands in the particular material. For example, if the band gap is between 1.65 and 2.00 electron volts ("eV"), red light is produced; if it is below 1.65 eV, invisible infrared light or heat is produced. If the band gap is between 2.51 and 2.76 eV, blue light is produced; if it is above that range, violet or ultraviolet light is produced.

Semiconductor materials with wide band gaps are more difficult to dope because they more readily become "compensated," meaning that impurities in the material supply electrons to fill the holes in p-type material or acceptors to receive the electrons in n-type material. This reduces incorporation of the dopants into the crystal lattice and unacceptably increases the resistivity of the semiconductor. Therefore red LEDs are much more easily produced and more commonly used than blue LEDs, which have been called "the long-sought Holy Grail of LED technology." (Puri Decl., Ex. 4.) The patents in suit concern methods for doping wide band gap semiconductor materials to make LEDs which emit shorter wavelength (green or blue) light.

The '618 Patent

In the Abstract section of the specification, the invention is summarized as follows:

> Non-equilibrium impurity incorporation is used to dope hard-to-dope crystals of wide band gap semiconductors, such as zinc selenide and zinc telluride. This involves incorporating into the crystal a compensating pair of primary and secondary dopants, thereby to increase the solubility of either dopant alone in the crystals. Thereafter, the secondary more mobile dopant is removed preferentially, leaving the primary dopant predominant. This technique is used to dope zinc selenide p-type by the use of nitrogen as the primary dopant and lithium as the secondary dopant.

Plaintiff charges both defendants with infringement of Claims 1, 4 and 5 of the '618 patent. Claims 1 and 5 are the only independent claims of the patent; Claim 4 is dependent on Claim 1 and contains no additional disputed terms. Claims 1 and 5 read as follows:

> 1. A process for the non-equilibrium incorporation of a dopant into a crystal of a wide band gap semiconductor comprising the steps of treating the crystal in the presence of first and second compensating dopants of different mobilities for introducing substantially equal amounts of the two dopants into at least a portion of the crystal such that the concentration of the less mobile of the two dopants in said portion of the crystal is in excess of the solubility therein of the less mobile dopant in the absence of the more mobile of the two dopants and then heating the crystal to remove therefrom preferentially the more mobile of the two dopants, whereby there is left a non-equilibrium concentration of the less mobile dopant in said portion of the crystal.
>
> 5. The process of forming a p-n junction diode in a crystal of a wide band gap semiconductor comprising the steps of
>
> preparing a crystal of the semiconductor of one conductivity type and growing on a surface of the crystal an epitaxial layer that includes a compensating pair of primary and secondary dopants in substantially equal amounts, such that the concentration of the primary dopant in the layer is in excess of the solubility of the primary dopant in the layer in the absence of the secondary dopant, where the primary dopant is characteristic of the conductivity type opposite that of said crystal and is less mobile than the secondary dopant, and
>
> removing selectively the secondary dopant from the layer to leave it of the opposite conductivity type, where the dopant remaining in the layer is predominantly the primary dopant in a non-equilibrium concentration.

The parties do not dispute the indicated construction of the following terms of the claims of

the‘618 patent:

“dopant” means an impurity added to a semiconductor material to alter its electronic properties;

“non-equilibrium incorporation” means incorporation of a dopant in excess of its equilibrium solubility at a particular temperature and concentration of compensating species;

“wide band gap” means a band gap of at least 1.4 eV;

“compensating dopant” means a dopant which provides either donors in p-type material or acceptors in n-type material;

“substantially equal amounts” means approximately equal molar quantities; and

“in excess of the solubility” means that the concentration of the less mobile dopant is greater than it would have been in the absence of the more mobile dopant.

The construction of the following terms of the ‘618 patent claims is in dispute:

“treating the crystal”

This term appears in Claim 1 and, by reference, in Claim 4, which is dependent on it. Claim 5 uses a different term, “preparing a crystal,” which will be discussed separately.

Plaintiff contends that this term should be defined as “subjecting the crystal to a process,” a definition which includes incorporation of dopant into a crystal during its growth. (Pl. Op. Br. at 15.)[2] Defendants contend that it should be defined as “ treating a pre-existing crystal.”

[2] The following abbreviations are used: Pl.=plaintiff; Lum.=Lumileds; Op.=opening; Opp.=opposing; Rep.=reply; Resp.= response; Br.=brief; Mem.=memorandum; Ex.=exhibit; Decl.=declaration; Tr.=transcript; Suppl.=supplemental.

The phrase "treating the crystal" does not appear in the specification of the '618 patent. However, in support of her proposed construction of the term, plaintiff points out that the specification of her contemporaneously filed '499 patent (at 2:39-42) states: "There are three conventional, non-esoteric methods for introducing dopants into the substrate: by diffusion, by implantation and during growth." Then, as examples of introduction of dopants during crystal growth, plaintiff refers to the specification of the '618 patent (at 2:50-52; 3:43-47; 4:19-25). These disclosures would clearly support a claim specifically calling for incorporation of dopants into a crystal of a semiconductor during growth of the crystal. However, merely because a procedure is disclosed in the specification does not mean that all of the claims of the patent should be construed so that their language covers that procedure as a step of the process claimed, particularly where there are other claims clearly covering a process which includes that step.

Cree points out that Claim 5 of the '618 patent calls for "preparing a crystal . . . and growing on a surface of the crystal an epitaxial layer that includes a compensating pair of primary and secondary dopants . . . ," and asserts that the "plain and ordinary meaning of this language requires that a substrate is first formed and then an epitaxial layer is grown on a surface of the substrate." (Cree Op. Br. at 34-35.) The Court agrees. But that does not mean that Claim 1 should also be so limited. It does not contain language similar to the quoted portion of Claim 5.

Lumileds points out (Lum. Op. Mem. at 12) that, in prosecuting in the European Patent Office ("EPO") a patent application based on and claiming priority from the applications for the two patents here in suit, plaintiff's attorney, in a letter to the EPO dated 21 February 1997 (*id.*, Ex. I), stated:

Thus, the dopants may be introduced into an existing crystal or may be introduced

> during its growth. However, since the reference in existing claim 1 to "treating the crystal . . ." could be construed as implying that the dopants are necessarily introduced into an otherwise fully formed crystal, this language has been removed from claim 1 so that this claim refers simply to "introducing into."

No such change was made in the corresponding Claim 1 of the U.S. '618 patent.

The statement of the patentee's attorney that the claim term in question "could be construed as implying" that the dopants are introduced into a fully formed crystal is merely a recognition of the obvious fact that the claim term is sufficiently ambiguous that it might be interpreted to require incorporation of the dopants into a pre-existing crystal. But it is not a concession that the claim term should be or would normally be interpreted to exclude introduction of the dopants during growth of the crystal. Indeed, defendants' argument is a two-edged sword: this clarification of the corresponding claim of the EPO application can also be viewed as evidence that plaintiff considered that the method of her invention contemplated incorporation of the dopants into a crystal during its growth.

The specification of the '618 patent resolves the issue. In the Detailed Description of the Invention, it describes only two illustrative examples of the patented method. At column 3, lines 16-62, there is described a method which involves growing on an n-type slice of zinc selenide an epitaxial p-type layer which is "grown by LPE [liquid phase epitaxy] to include both lithium and nitrogen." At column 4, lines 10-45, there is described an "alternative embodiment" which involves growing on a p-type slice of zinc telluride an n-type epitaxial layer which is grown by MOCVD (metal-organo-chemical vapor deposition) to incorporate chlorine as the primary dopant and lithium as the secondary dopant. Thus, in both of the two exemplary methods, the dopants are introduced into the epitaxial crystal during its growth. More significantly, there is no detailed description of a

method in which the dopants are introduced into a pre-existing crystal, although the specification (at 5:1-2) briefly mentions that "other techniques are feasible including molecular beam epitaxy." Therefore, if, as defendants urge, the term in question were construed to require treatment of a pre-existing crystal, a serious question would be raised about the validity of Claim 1 under 35 U.S.C. §112, first paragraph, based on lack of an enabling disclosure. *See Nat'l Recovery Techs. v. Magnetic Separation Sys., Inc.,* 166 F.3d 1190 (Fed. Cir. 1999).

The Court concludes that a person of ordinary skill in the art, reading the '618 patent specification and seeing that, in <u>both</u> of the <u>only</u> detailed examples described, the dopants are incorporated during crystal growth, would understand that the term "treating the crystal" was meant to cover that alternative.

The Court therefore construes the term "treating the crystal" to mean:

subjecting the crystal to a process which may occur during its growth.

<u>"remove" or "removing"</u>

Plaintiff contends that this term, which appears in both Claims 1 and 5, should be construed to mean "taking away." Plaintiff adds that the term really needs no construction by the Court, but if it does, it should be construed to mean taking away "an effective amount of the . . . more mobile dopant." (Pl. Op. Br. at 14.)

Lumileds states that plaintiff's proposed definition hardly clarifies the term, and that it "can only mean either partial or complete 'taking away'." (Lum. Opp. Mem. at 5.)

Cree contends that the term should be construed to require that the more mobile dopant be removed "so that it is no longer within the semiconductor," in other words, "not just moving the

dopant to other locations within the crystal/layer." (Cree Op. Br. at 36-37.) The Court agrees that the definition should make clear that the portion of the more mobile dopant which is removed is taken entirely out of the crystal and not merely moved within it. Such a meaning is indicated not only by the choice of the word "<u>re</u>move" instead of "move" but also by the language in Claim 1 which calls for "heating the crystal to remove <u>therefrom</u> preferentially the more mobile of the two dopants . . ." (emphasis added). The specification contains similar language; in the Detailed Description of the first illustrative method at column 3, lines 51-52, it is stated ". . . the lithium is preferentially removed <u>from</u> the epitaxial layer." (emphasis added). This concept is probably expressed adequately by the words "taking away" proposed by plaintiff and accepted by Lumileds. But to avoid any possibility of misconstruction, the words "from the crystal" should be added. The Court also believes that the definition should make it clear that it does not require that <u>all</u> of the more mobile dopant be removed from the host crystal but does require removal of a quantity sufficient to achieve the result recited in the specification, which is that the less mobile dopant "becomes the predominant dopant in the epitaxial layer . . . ." (4:42-43.)

The Court therefore concludes that the term should be construed to mean:

taking away from the crystal an effective portion.

<u>"epitaxial layer"</u>

In the '618 patent, this term appears only in Claim 5.

Plaintiff proposes that it be construed as "a thin layer of grown crystalline material." (Pl. Op. Br. at 19.)

Lumileds does not oppose that construction. (Lum. Opp. Mem. at 10.)

Cree proposes that the term be construed as "a layer formed on an underlying substrate by an epitaxial growth process." (Cree Op. Br. at 35.)

In their opening briefs, both plaintiff (Pl. Op. Br. at 19) and Cree (Cree Op. Br. at 36) support their respective proposed constructions by referring to the single figure of the patent drawing and quoting from the same portion of the'618 patent specification (3:32-35) which describes a step in the first illustrative process: "Thereafter, there is grown on one surface of the n-type slice . . . an epitaxial p-type layer . . ., typically between 5 and 10 microns thick, although even thinner layers can be used." They could have referred as well to the description of the corresponding step in the "alternative embodiment" (4:20-21): " . . . an n-type epitaxial layer is grown on the top surface of the slice."

The only difference between the two proposed constructions is that Cree's version requires that the layer be grown on an "underlying substrate." Because in the drawing and in both of the illustrative processes described in the specification of the '618 patent, the epitaxial layer is grown on a slice of semiconductor crystal, the specification would support Cree's version but, as discussed below, it is also consistent with plaintiff's version.

In its reply brief (Cree Resp. Br. at 42), Cree quotes from two dictionaries, Merriam-Webster's (*id.*, Ex. SS at 391) and Webster's New Collegiate (*id.*, Ex. TT at 382) the identical definition of the word "epitaxy": "the growth on a crystalline substrate of a crystalline substance that mimics the orientation of the substrate." Although plaintiff supported her proposed construction of other disputed terms by citing definitions from so many different dictionaries that defendants accuse her of "cherry-picking" dictionaries for definitions favorable to her position (*e.g.,* Cree Rep. Br. at 1-2), she cites no definition for the term "epitaxial layer" differing from that quoted above. The

Court therefore believes that this definition represents the common and ordinary meaning of the term to persons of ordinary skill in the semiconductor art both now and in 1988. Thus "epitaxial" growth of a crystalline layer requires an underlying base whose crystalline structure determines that of the epitaxial layer.

However, the underlying crystalline base could be another epitaxial layer. At the *Markman* hearing (Tr. 184-88), plaintiff's counsel pointed out that an epitaxial layer could be grown on top of another epitaxial layer, in which event the lower epitaxial layer would serve as a "substrate" for the one above it. Cree's counsel did not disagree with this construction: "So I just want to be clear that, with respect to the epitaxial issue, we're not arguing the layer has to be directly on the substrate, there could be an intervening layer." (Tr. 189.) Thus, the term "epitaxial layer" should not be construed to require that it be deposited on a "substrate," which might create doubt as to whether it would cover an epitaxial layer grown on the upper surface of an underlying epitaxial layer. The generic word "base" is preferable because it clearly is sufficiently broad to cover that alternative.

The Court therefore construes the term "epitaxial layer" to mean:

a thin layer formed by epitaxial growth on a crystalline base.

<u>"preparing a crystal . . . and growing on a surface of the crystal"</u>

This term appears only in Claim 5 of the '618 patent.

Plaintiff has neither proffered any proposed construction of this term nor made any specific argument in opposition to the construction proposed by Cree. Lumileds likewise does not discuss it.

Cree proposes that it be construed to require that "a substrate is first formed, and then an

epitaxial layer is grown on a surface of the substrate." (Cree Op. Br. at 34.) Cree supports its proposal by contending that is required by the "plain and ordinary meaning" of the language and is supported by the specification of the '618 patent. The Court agrees. In both of the two embodiments of the patented process described in the specification, a semiconductor crystal is first formed and then on one surface of a slice of that crystal an epitaxial layer is grown. The first embodiment is described as follows: "There is <u>first prepared</u> the n-type slice of zinc selenide" (3:19-20, emphasis added); this is followed by "cutting a slice" and "annealing the slice in molten zinc." (3:25-27.) "<u>Thereafter</u>, there is grown on one surface of the n-type slice 12, an epitaxial p-type layer 14 . . . ." (3:32-33, emphasis added.) The second embodiment involves similar steps: "A p-type crystal of ZnSe was grown from a Te rich solution . . . . " (4:13-14.) "<u>Then</u> in known fashion, using metal-organo-chemical vapor deposition (MOCVD), an n-type epitaxial layer is grown on the top surface of the slice." (4:19-21, emphasis added.) The specification contains no description of any process that does not involve such a sequence of steps.

Thus, insofar as Cree's proposed construction calls for first preparing a crystal and thereafter growing on a surface of the crystal an epitaxial layer, the Court agrees, but does not believe that the underlying crystal should be called a "substrate" as Cree proposes. As discussed above with reference to the term "epitaxial layer," one epitaxial layer may be grown on top of another. The Court sees no reason to define the present term so as to create doubt whether it covers such an embodiment.

Therefore the term "preparing a crystal . . . and growing on a surface of the crystal" is construed to mean:

first preparing a crystal . . . and thereafter growing on a surface of the crystal.

<u>The ‘499 patent</u>

The Abstract of the ‘499 patent summarizes the invention as follows:

> A wide band-gap semiconductor, such as a II-VI semiconductor having low bipolar resistivity and a method for producing such a semiconductor. To form this semiconductor, atomic hydrogen is used to neutralize compensating contaminants. Alternatively, the semiconductor dopant and hydrogen are introduced into the undoped semiconductor together, and later, the hydrogen is removed leaving an acceptably compensation free wide band-gap semiconductor.

(Puri Decl., Ex. 2.)

Plaintiff charges both defendants with infringement of Claims 10, 12-14 and 16-20 of the ‘499 patent. Of these claims, only Claim 10 is an independent claim and all of the others are dependent upon it, either directly or indirectly. All of the claim terms whose construction is disputed are in Claim 10, which reads as follows:

> 10. A method of forming a low resistivity semiconductor from a wide band-gap semiconductor substrate that has a tendency to become compensated when it is doped, comprising selectively doping the semiconductor substrate with an effective amount of dopant to induce acceptable conductivity, together with an effective amount of atomic hydrogen to act as a compensator and block unacceptably high occurrences of other compensators, then removing an effective amount of the added hydrogen to reduce the resistivity of the semiconductor, the hydrogen removed under conditions to limit other movement within the semiconductor.

(*Id.*)

All parties agree the following terms in Claim 10 should be construed as indicated:

“wide band gap” means a band gap of at least about 1.4 eV;[3]

“a tendency to become compensated” means a tendency to incorporate donors in p-type

[3] This definition differs from that given to the same term with respect to the ‘618 patent only in the addition of the word “about.” The reason for the difference is that the specification of the ‘499 patent uses that word in defining “wide band gap” and the specification of the ‘618 patent does not. (Tr. 6-7, 171.)

material and acceptors in n-type material;

"effective amount" means a quantity sufficient to produce the recited result;

"atomic hydrogen" means hydrogen atoms not bonded to other atoms;

"block unacceptably high occurrences of other compensators" means block the formation or introduction of other compensators that would otherwise have resulted in a high resistivity semiconductor; and

"limit other movement" means limit changes in the crystal structure and location of dopants in the semiconductor.

The construction of the following terms in Claim 10 is disputed:

"forming . . . from"

Plaintiff proposes that this term be construed to mean "producing from." (Pl. Resp. to Cree at 13.)

Cree proposes that it be construed to require "that the low resistivity semiconductor is formed by doping a **pre-existing** wide band-gap semiconductor substrate." (Cree Op. Br. at 7, emphasis in original.)

Lumileds agrees with Cree that the substrate must be pre-existing. (Lum. Op. Mem. at 11.)

Plaintiff merges her discussion of this term with her discussion of the term "treating the crystal" which does not appear in Claim 10 or any other claim of the '499 but only in Claim 1 of the '618 patent. (Pl. Resp. to Cree at 13.) She contends that neither of these terms should be construed to require a pre-existing crystal or substrate because the specifications of both patents disclose embodiments in which growth and doping occur simultaneously (*id*. at 15). As discussed above, we

agree that the term "treating the crystal" should be construed so that it does not require a pre-existing crystal because, in both of the embodiments described in detail in the specification of the '618 patent, the dopant is incorporated into the epitaxial layer during its growth. However the specification of the '499 patent tells a different story. As plaintiff herself states, the '499 patent discloses three different methods for doping a semiconductor, in the first two of which, diffusion (5:8-21) and ion implantation (5:26-27), the substrate is doped after it is grown. (Pl. Resp. to Cree at 14.) Although the specification (5:22-23) also discloses a third method in which the substrate is doped during its growth, that does not mean that Claim 10 should be construed broadly enough to cover that third method if the words of the claim, read in light of the specification and the prosecution history, clearly indicate otherwise.

As defendants contend, that is the situation here. First, the words themselves strongly suggest that there must be a pre-existing substrate. To form a silk purse from a sow's ear, you must first have a sow's ear. And to form "a low resistivity semiconductor from a wide band-gap semiconductor substrate," you must have a pre-existing substrate. This usual meaning of the words is reinforced by the intrinsic evidence. The application for the '499 patent as filed contained both method and product claims. The Examiner issued a restriction requirement, which required that the applicant select either the method claims or the product claims for prosecution. The Examiner explained:

> In the instant case unpatentability of the group I invention [the product claims] would not necessarily imply unpatentability of the group II invention [the method claims], since the device of the group I invention could be made by [a process] materially different from those of the group II invention, e.g., <u>hydrogen can be incorporated into the semiconductor during growth rather than introduction of hydrogen into the semiconductor after it [is] grown, as is claimed in the instant application.</u>

(Cree Op. Br., Ex. B at 2, emphasis added.) Plaintiff did not challenge this construction of the method claims, but merely elected to prosecute them in the pending application; she did not file another application containing the product claims, which would clearly have covered semiconductors in which the dopant and hydrogen are introduced during growth of the substrate.

The Court therefore concludes that the term "forming . . . from" should be construed to mean:

forming from a pre-existing substrate.

"substrate"

Plaintiff proposes that this term should be defined as "any semiconductor material." (Pl. Op. Br. at 20.)

Cree proposes that it be defined as "a slice of semiconductor that is used as a base material, as opposed to epitaxial layers that are grown on a substrate." (Cree Op. Br. at 10.)

Lumileds does not advance a proposed definition of its own, except to agree with Cree that "the substrate must be pre-existing." (Lum. Opp. Mem. at 11.) However, Lumileds offers the following criticism of the proposals of the other parties: "'Substrate' clearly should not be construed to include a 'semiconductor' definition or modifier. Claim 10 already explicitly recites a 'semiconductor substrate.'" (*Id.*) The Court agrees that the definition should not include the redundant modifier "semiconductor."

In support of her proposed construction of the term, plaintiff states that it is "consistent with its use in claim 10, which recites that the 'substrate . . . has a tendency to become compensated when it is doped . . . .'" (Pl. Op. Br. at 20.) But this description of the "substrate" in Claim 10 does not support plaintiff's proposed definition of the term as "any semiconductor material." Plaintiff adds

that "[h]ard to dope semiconductor materials, such as hard to dope epitaxial layers, are necessarily a substrate in the context of this claim, of [sic] having a tendency to become compensated when they are doped. This is supported by the specification which, in describing the various methods for introducing dopants . . . is applicable to any semiconductor material that is hard to dope." (*Id.*) In this bewildering non-sequitur, plaintiff seems to be saying that any material that is hard to dope is a "substrate" because her invention is applicable to any material that is hard to dope. But her proposed definition makes no mention of difficulty in doping. Nor should it; such a modifier would be redundant because Claim 10 already calls for a "substrate that tends to become compensated when it is doped." Apparently, plaintiff's real interest is in obtaining for the term "substrate" a construction broad enough to cover epitaxial layers.

Cree takes the diametrically opposite position that a "substrate" cannot be an epitaxial layer, and that it "should be given its plain and ordinary meaning . . . ." (Cree Op. Br. at 10.) Cree supports its position by quoting from plaintiff's deposition:

> Q: Is it your understanding that the plain, at least in 1988, that the plain and ordinary meaning of substrate refers to a slice of semiconductor used as a base material on which a semiconductor device is formed?
>
> A: It was the most customary usage, but again, I did not think that was material as long as it was clear from the patent.
>
> Q: Is it your understanding that the customary usage of the term "substrate" in 1988 did not refer to a thin epitaxial semiconductor layer deposited on a base material?
>
> A: Well, again, it was more common usage that substrate was something you deposited something on. . . .

(Cree Op. Br. at 10, Ex. A (Neumark Dep. at 136:21-137:11).) However, contrary to Cree's inference, plaintiff's answers to these leading questions do not constitute an admission that the term

"substrate," as used in the claims of the '499 patent, does not cover a thin epitaxial layer, but only that in 1988 "the most customary usage" of the term was to refer to "a slice of semiconductor material used as a base" or "something you deposited something else on." This does not exclude construction of the term to apply to an epitaxial layer which is used as a base on which another epitaxial layer is deposited.

Cree further argues that the intrinsic evidence supports its proposed construction: the term "substrate" is used five times in the specification of the '499 patent but never to refer to an epitaxial layer grown on a base material. Indeed, the Detailed Description of the Preferred Embodiments begins: "To produce an adequately conducting wide band-gap semiconductor, a dopant must be introduced into a semiconductor substrate material." (2:38-40, emphasis added.) However, this begs the question whether the term "substrate" can apply to an epitaxial layer. Plaintiff argues that she invented "a technique for doping any hard to dope wide band gap semiconductor" and that it would defy common sense for her to "limit that technique to just the base material of the semiconductor device to the exclusion of wide band gap epitaxial layers." (Pl. Resp. to Cree at 5.) But this also begs the question. It is immaterial that plaintiff believes she invented a technique for treating any semiconductor material unless her patent fairly teaches those of ordinary skill in the art that her invention can be employed in the treatment of semiconductor materials other than bulk crystal substrates.

The specification of the '499 patent discloses several specific examples of processes in which atomic hydrogen is introduced into the p-type side of a p-n junction to neutralize compensating donors or into the n-type side to neutralize compensating acceptors. (4:41-47.) Although none of the materials into which the atomic hydrogen is introduced is identified either as a substrate or as an

epitaxial layer, in her post-hearing memorandum (Pl. Suppl. Mem. at 2-3), plaintiff argues that the temperatures specified for the introduction of hydrogen and the dopant are those appropriate for epitaxial growth and not for growth of a bulk crystal substrate. Thus the specification (at 5:22-26) states:

> A second method of simultaneous H and dopant introduction is to introduce both during crystal growth. One condition is that the growth temperature is adequately low to maintain the presence of H. Therefore, temperature of about 700º C. and below is desirable.

As plaintiff points out, all of the semiconductor materials discussed in the patent have melting temperatures of at least 1100º C., so in this example she was clearly talking about introduction during growth of an epitaxial layer and not during growth of a bulk crystal from a melt.

Plaintiff has not shown that she has ever used the word "substrate" with specific reference to an epitaxial layer, although the record contains many examples of her use of the term to refer to a slice of a bulk crystal which serves as a base for the growth of an epitaxial layer on its upper surface. For example, in her contemporaneously filed '618 patent in suit, she used the word "substrate" only in one paragraph of the Summary of the Invention in which it is stated: "If a p-n junction is to be formed, an n-type zinc selenide crystal is used as the substrate in the LPE process [by] which the lithium-nitrogen epitaxial layer is grown." (2:67-3:1.) In the two examples in the Detailed Description of the Invention, she referred to the substrate element as a "slice" cut from "a single crystal boule of n-type zinc selenide" (3:23-27) or from "a p-type crystal of ZnSe" (4:13.)

In her deposition, plaintiff conceded that her '499 patent contained no clear disclosure of an intention to use the term "substrate" in any way other than its customary meaning in the art:

> Q: Do you recall putting any disclosure in your '499 patent that makes clear that your use of the term "substrate" was being used in a manner different than its plain and

ordinary meaning in 1988?

A: I don't think there was.

(Cree Op. Br., Ex. A (Neumark Dep. at 140:16-21).) In the absence of a clearly disclosed special meaning, the term must be given its customary meaning to a person of ordinary skill in the art. *See Markman*, 52 F.3d at 980 ("any special definition . . . must be clearly defined in the specification"); *Merck & Co. v. Teva Pharm. USA, Inc.,* 395 F.3d 1364, 1370 (Fed. Cir. 2005) ("We have repeatedly emphasized that the statement in the specification must have sufficient clarity to put one reasonably skilled in the art on notice that the inventor intended to redefine the claim term.")

In her post-hearing memorandum (Pl. Suppl. Mem. at 4-5) plaintiff quotes from three U. S. patents and two publications (all of Japanese patentees or authors) in which a semiconductor component is referred to as an "epitaxial substrate." However, in all of those patents or publications, that phrase was used to refer to a substrate or base on which an epitaxial layer is grown; indeed, in one of them (Puri Suppl. Decl., Ex. E at 2:51-54), it is specifically so defined: "The present invention . . . has an object to provide a method for preparing simply and in short time a substrate for epitaxial growth (hereinafter referred [to] as 'the epitaxial-substrate')." In none of them do we find the word "substrate" applied to the epitaxial layer itself. However, consistent with what was said above in discussing the term "epitaxial layer" in the '618 patent, if, but only if, an epitaxial layer serves as a supporting base for another epitaxial layer grown on its upper surface, the underlying epitaxial layer may properly be described as a "substrate" for the layer above. Thus, in defining the term "substrate," we do not believe it appropriate, as advocated by Cree, either to specifically exclude epitaxial layers or to do so impliedly by use of the word "slice," which is appropriate only with reference to bulk crystals.

The Court therefore construes the term "substrate" to mean:

an underlying base on which an epitaxial layer is grown.

"together with"

Plaintiff states that this phrase is easily understood and needs no construction by the Court, but adds that if the Court is inclined to construe it, it should be construed to mean "along with." (Pl. Op. Br. at 25.)

Lumileds does not challenge this definition, although characterizing it as "little more than a paraphrase . . . ." (Lum. Opp. Mem. at 16.)

Cree proposes that the term be construed to require "that the dopant and the atomic hydrogen are introduced simultaneously into the semiconductor substrate." (Cree Op. Br. at 19.)

Plaintiff supports her proposed construction by citing the use of the phrase "along with" in the specification of the '499 patent (*e.g.,* at 5:33; 6:9) and by citation of Webster's New Collegiate Dictionary, which defines the term as "in addition to; in association with." (Pl. Op. Br. at 25.) However, these definitions are consistent with simultaneous introduction of the two dopants.

Cree contends that the specification of the '499 patent uses the words "together with" and "simultaneously" interchangeably. The Court agrees. The paragraph commencing at line 8 of column 5 begins: "A first method of introducing H and dopant together into the semiconductor, is the joint diffusion method." (Emphasis added.) Then, after discussing the workable temperatures for such diffusion, the paragraph concludes: "Accordingly, a wide range of conditions and temperatures are available for the simultaneous introduction of H and dopant by joint diffusion." (5:18-21, emphasis added.) The next paragraph begins: "A second method of simultaneous H and

dopant introduction is to introduce both during crystal growth." (5:22-23, emphasis added.)

Cree also relies on the following testimony at plaintiff's deposition:

> Q: Does [Claim 10] of your '499 patent also require that the hydrogen and dopant be put in simultaneously?
>
> A. It says together.
>
> Q: And so your interpretation is that the atomic hydrogen and the dopant need to be introduced into the semiconductor simultaneously at the same time?
>
> A: Yes.

(Cree Op. Br., Ex. A (Neumark Dep. at 177:10-18.) Thus, the construction proposed by Cree is supported not only by the intrinsic evidence of the specification, but by the testimony of the patentee herself. That construction is not inconsistent with the portions of the specification or the dictionary definitions cited by plaintiff.

The Court therefore concludes that the term "together with" should be construed to mean:

"simultaneously with."

"doping . . . with . . . atomic hydrogen"

As indicated above, the parties agree that the term "atomic hydrogen" refers to atoms of hydrogen not bonded to other atoms. However, they disagree on the meaning of the term "doping . . . with . . . atomic hydrogen."

Plaintiff contends that it covers doping with atomic hydrogen resulting from the dissociation of hydrogen-containing gases (Pl. Resp. to Cree at 9.) Cree contends that it should be construed to mean "adding atomic hydrogen to the semiconductor substrate" and cannot cover introduction into the substrate of hydrogen originating from hydrogen-containing gases. (Cree Op. Br. at 18.)

Lumileds agrees with Cree but adds that the term being defined should include the full phrase "selectively doping" which appears in Claim 10 and argues that the failure to define the word "selectively" in the specification renders the claim invalid under 35 U.S.C. § 112. (Lum. Opp. Mem. at 14.)

Both defendants contend that during prosecution of the application for the '499 patent, plaintiff disclaimed coverage of processes in which atomic hydrogen is inherently introduced into the substrate by the breakdown of ambient hydrogen-containing gases, such as molecular hydrogen or ammonia. (Cree Op. Br. at 14; Lum. Opp. Mem. at 15.) In an Office Action dated July 20, 1990 (Cree Op. Br., Ex. B), the Examiner rejected application claim 20 (patent Claim 10) as anticipated by or obvious in view of a prior article of Fan, *et al.*, stating:

> Fan discloses a process for obtaining a low resistivity n-type ZnSe film comprising the step of epitaxially growing the ZnSe layer using dimethylzinc and hydrogen selenide with hydrogen as a diluent. The substrate temperature is about 280º C. Since in the Fan process the crystal is grown in a hydrogen ambient it is believed that hydrogen is inherently incorporated into the ZnSe layer. Further in all such processes it is customary to evacuate the reaction chamber after the completion of the crystal growth therefore some hydrogen would inherently be removed from the ZnSe epitaxial layer.

(*Id*. at 5, emphasis added.) Plaintiff did not dispute this statement, but in a Supplemental Amendment dated March 8, 1991, distinguished the claimed invention by stating: " . . . the Fan reference does not anticipate or render obvious applicant's method, as suggested by the Examiner. Fan describes the use of molecular hydrogen (H_2 gas). Claim 20 [patent Claim 10] specifically describes the use of atomic hydrogen." (*Id.*, Ex. F at 2.) And, in a second Information Disclosure Statement ("IDS") dated March 8, 1991 (*id.*, Ex. N at 3), plaintiff stated: " . . . the prior art cited pursuant to 37 C.F.R. §1.56 does not teach or suggest applicant's claims in that none of the

references describe the use of atomic hydrogen to prevent compensation . . . ."

Defendants argue that, having thus distinguished her invention on the basis of her use of "atomic hydrogen as originally supplied, contrasted with the prior art's atomic hydrogen derived from hydrogen-containing . . . gases," plaintiff is "estopped to assert that 'atomic hydrogen' can be derived from any hydrogen-containing process or carrier gases." (Lum. Opp. Mem. at 14; Cree Op. Mem. at 14-18.)

Plaintiff responds that, in differentiating her invention from the disclosure of Fan, she did not rely merely on Fan's use of molecular hydrogen, but also on the facts that Fan did not dope the type of substrate called for in Claim 10 and did not thereafter remove any of the hydrogen as called for in that claim. Thus, in an Amendment filed January 22, 1991 (Puri Decl., Ex. 12 at 4), she stated:

> [O]ne seeking to form a low resistivity semiconductor from material that has a tendency to become compensated (p-type ZnSe), as required by the claims, would not look to Fan because Fan discusses a method of forming a semiconductor (n– type ZnSe) that does not have that tendency to become compensated.
>
> Fan does not describe that the introduction of hydrogen with dopant, followed by the subsequent removal of hydrogen, can provide low resistivity in materials that have a tendency to become compensated. Moreover, Fan does not describe that the inclusion and then the removal of hydrogen will prevent compensation in materials that tend to become compensated.

Plaintiff further argues that neither Fan nor any of the other cited references discloses a method of co-doping a wide band gap semiconductor using either original source atomic hydrogen or dissociated atomic hydrogen and thereafter removing said hydrogen. She explains that even if, in the processes of the prior art, atomic hydrogen was introduced accidentally, the references would still not teach her method of forming low resistivity bipolar semiconductors. Thus there was no need for her to disclaim something that was not anticipatory. (Pl. Resp. to Cree at 10-11.) She adds that it would have been illogical for her to disclaim the use of dissociated atomic hydrogen, because

atomic hydrogen is highly unstable and cannot be found in nature but must be obtained by dissociation from another molecule. (*Id.*)

But the mere fact that a disclaimer was both unnecessary and illogical does not avoid its binding effect. If, in attempting to persuade the Examiner to allow a claim, the applicant clearly gives a term in the claim a narrow construction, the public is entitled to rely on that construction, even though the claim might have been allowed with a broader construction. As stated in *Springs Window Fashion LP v. Novo Indus., L.P.*, 323 F.3d 989, 995 (Fed. Cir. 2003):

> The public notice function of a patent and its prosecution history requires that a patentee be held to what he declares during the prosecution of his patent. . . . The prosecution history constitutes a public record of the patentee's representations concerning the scope and meaning of the claims, and competitors are entitled to rely on those representations when ascertaining the degree of lawful conduct. . . . Were we to accept [the patentee's] position, we would undercut the public's reliance on a statement that was in the public record and upon which reasonable competitors formed their business strategies.

(Internal quotations omitted, citations omitted.) And in *Atofina v. Great Lakes Chem. Corp.,* 441 F.3d 991, 998 (Fed. Cir. 2006) the Court added:

> That the applicants only needed to surrender nickel-chromium catalysts to avoid a prior art reference does not mean that its disclaimer was limited to that subject matter. To the contrary, it frequently happens that patentees surrender more through amendment than may have been absolutely necessary to avoid particular prior art. In such cases, we have held the patentees to the scope of what they ultimately claim, and we have not allowed them to assert that claims should be interpreted as if they had surrendered only what they had to.

(Internal quotations omitted, citations omitted.)

The Examiner was apparently correct in stating that, in the process disclosed in the Fan, *et al.* article, the growth of a ZnSe epitaxial layer in a flow of hydrogen gas at a temperature of 240º C to 340º C inherently results in the introduction of atomic hydrogen into the epitaxial layer and that

the subsequent evacuation of the reaction chamber inherently removes some of the hydrogen. But whether he was correct or not is immaterial to the present inquiry. Plaintiff did not challenge the statement, but instead distinguished the Fan reference on the basis that it describes the use of molecular hydrogen gas and not "atomic hydrogen" as specified in Claim 10 of the '499 patent. Plaintiff thus made clear her position that the claim term "doping . . . with . . . atomic hydrogen" did not cover the incidental incorporation of atomic hydrogen resulting from the breakdown of ambient hydrogen-containing gases.

It is likewise immaterial that plaintiff also pointed out other distinctions from Fan including the fact that Fan was not doping a "substrate that has a tendency to become compensated when it is doped," and did not thereafter "remov[e] an effective amount of the added hydrogen," as called for in the claim. We do not know whether the claim would have been allowed on the basis of these distinctions alone. We only know that plaintiff, in arguing the patentability of her invention over Fan, did not rely only on those differences but also on a limited construction of the term "doping . . . with . . . atomic hydrogen" and that construction is binding on her whether or not the Examiner relied upon it in allowing the claim. As the Court stated in *Microsoft Corp. v. Multi-Tech Sys., Inc.,* 357 F.3d 1340, 1350 (Fed. Cir. 2004):

> We have stated on numerous occasions that a patentee's statements during prosecution, whether relied on by the examiner or not, are relevant to claim interpretation. *Laitram Corp. [v. Morehouse Indus., Inc.,* 143 F.3d 1456, 1462 (Fed. Cir. 1998)] ("The fact that an examiner placed no reliance on an applicant's statement distinguishing prior art does not mean that the statement is inconsequential for purposes of claim construction.").

The specification of the '499 patent gives further support to this limited construction. It nowhere suggests that the atomic hydrogen introduced into the substrate can be provided simply by

disintegration of ambient molecular hydrogen or other hydrogen-containing gas. But in the paragraph beginning at Column 3, line 62 it does discuss two "known" processes for introducing atomic hydrogen into a semiconductor described in an article of Chevallier, *et al.* One of the processes utilizes "a parallel plate reactor operating at a low frequency of about (30 kHz)" (3:67-68) and the other employs "a two electrode cell having H_3PO_4 as electrolyte . . . ." (4:5.) If plaintiff had actually intended that the claim under discussion would cover the incorporation of atomic hydrogen derived from whatever source, including the inherent breakdown of ambient molecular hydrogen or other hydrogen-containing gas, she would not likely have omitted any mention of that possibility while disclosing two much more cumbersome (and presumably more expensive) methods of creating atomic hydrogen.

A person of ordinary skill in the art with knowledge of this intrinsic evidence would surely be led to understand that Claim 10 does not cover a process in which the atomic hydrogen introduced into the substrate is that inherently produced by the breakdown of ambient hydrogen-containing gases.

The Court therefore concludes that the term "doping . . . with . . . atomic hydrogen" should be construed to mean:

incorporating atomic hydrogen not produced by disintegration of ambient gases.

SO ORDERED.

Dated: White Plains, NY
May 3, 2007

William C. Conner

WILLIAM C. CONNER, Senior U.S.D.J.